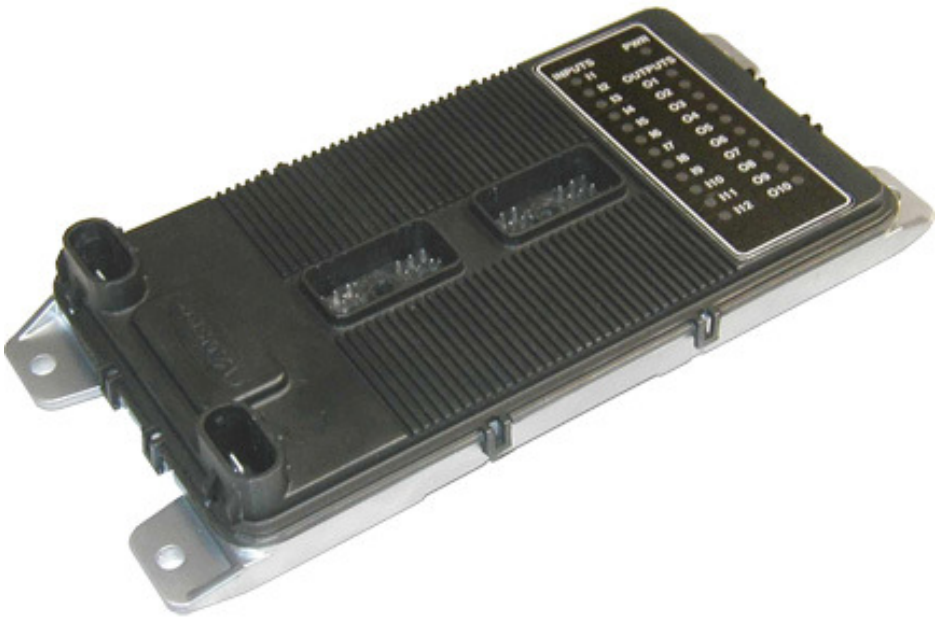
VMM1210

Vansco Multiplex Module 1210



Hardware and Software User Manual

UM-VMM1210-736000-XX-200812-01

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1. Introduction

This user guide will introduce the Vansco Multiplex Module Model 1210 (VMM1210) and describe its use in a typical vehicular electrical system. The aim of the document is to supply a full specification for the VMM1210 and allow the reader enough insight to use the VMM1210 to its full potential.

2. VMM1210 Module Description

The VMM1210 is a general purpose programmable logic controller (PLC) for vehicle and other DC applications with steady state voltages less than 32V. It has 12 inputs and 10 outputs as well as a CAN/J1939 communication port and an RS232 programming port. This module is 100% compatible with the VMM2820 module as well as other Parker Vansco Multiplex System products and can be used with or without VMM2820s.

The VMM1210 performs the following tasks:

- Receives digital/analog/frequency inputs:

  The VMM1210 has 8 digital inputs capable of reading either active high or active low type inputs. In addition, it has 4 inputs capable of reading analog voltages, frequency values or digital active low type inputs.

- Activates outputs:

  The VMM1210 has 8 high current (10 A max) high-side outputs. In addition it has two low current (3 A max) outputs capable of driving either high-side or low-side loads and can also be arranged in an H-Bridge configuration. Outputs can drive any type of vehicle load including lights, relays, solenoids, fans, etc.

- Monitors outputs:

  The VMM1210 monitors its 10 outputs continuously for fault information. Faults include short circuits (to ground or power), over currents and open load. The VMM1210 allows systems to reduce the number of fuses by allowing the outputs to protect themselves electronically. In the event of a fault, the VMM1210 will disable the output(s) that are faulted. The automatic recovery of faulted states can be turned on or off (for safety reasons). As well, if turned on, the automatic fault retry can be adjusted to suit a variety of safety related situations. Open load detection allows for the detection of open (burnt out) loads, this detection can be turned on or off and can also be modified to check only at power up of the system or continuously. Over current levels can be adjusted in one amp increments anywhere from 1 A to 12 A to allow the system to react more like various fuse types.

- Communicates input/output state information:

  In order to multiplex, the VMM1210 must be able to communicate its information to other CAN/J1939 based equipment in the vehicle. The VMM1210 does this by transmitting J1939 messages representing the states of its inputs and outputs and other ladder logic based equipment. These messages are broadcast

type and can be read by and acted on by any other module connected to the same CAN/J1939 network.

- Processes ladder logic:

  Ladder logic is a graphical representation of standard logic (AND, OR, NOT, etc.). The VMM1210 processes ladder logic written using the Vansco Multiplex Module Software package (VMMS). The ladder logic defines which inputs or arrangement of inputs turns on which outputs on the module. The inputs and outputs in the ladder logic can be from one or more modules connected together in a system via the CAN/J1939 network. For more information on the VMMS package, please refer to the VMMS User Guide, or the VMMS help files for information.

The VMM1210 can be connected to various types of inputs and loads to allow the transmission of input and output state information to other areas of the vehicle as shown in Figure 1.

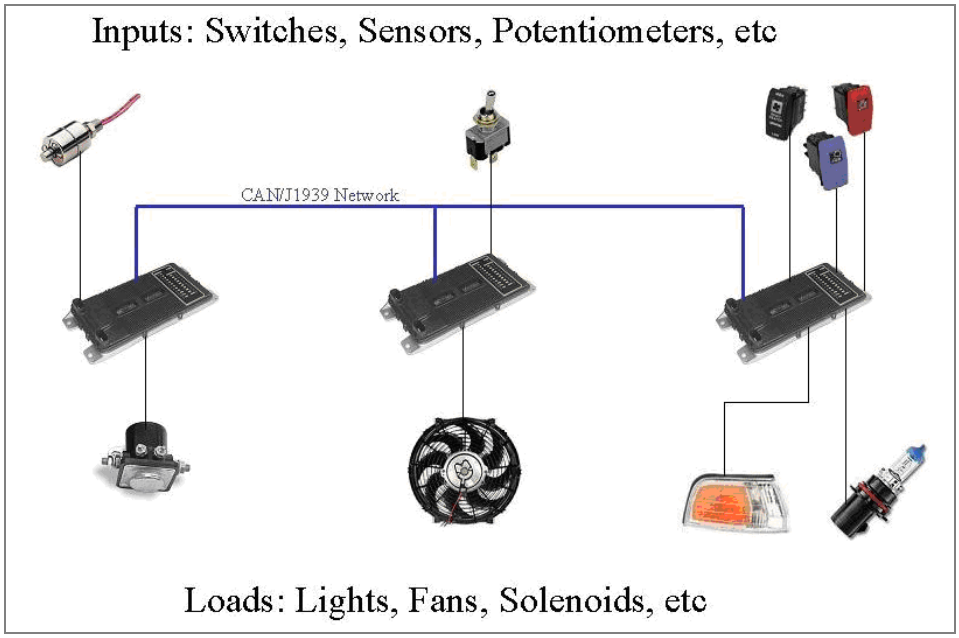


Figure 1: VMM input / output types

The versatility of the VMM1210, using the industry standard CAN/J1939 network, allows the VMM1210 to be connected to virtually any other J1939-based device on the market, including all of the Parker Vansco-offered CAN/J1939 based products. In addition, the VMM1210 can be linked via a Parker Vansco Pocket Gateway Module (PGM) allowing it to remain isolated from the drive train network and to communicate with devices on other networks such as J1708.

Figure 2 shows the arrangement of VMM1210s and the CAN/J1939 network in a typical vehicle application:

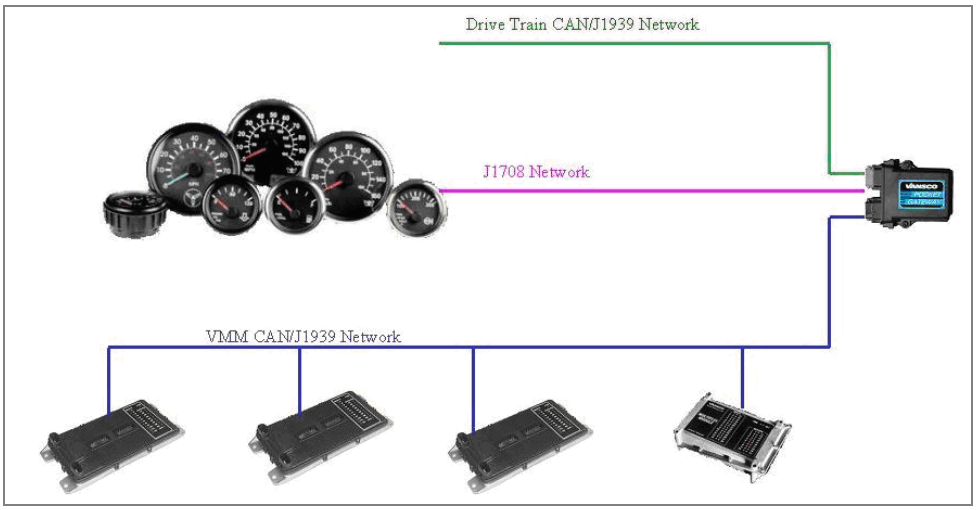


Figure 2: CAN/J1939 arrangement in a VMM system

In a typical arrangement, the VMM1210 is placed at various locations in a vehicle (front, rear, top, and bottom) and all are linked via the CAN/J1939 twisted-pair-shielded-cable. This arrangement allows the modules to act as multiplexors in that they all receive inputs and drive outputs in their respective zones, but also communicate that input/output state information to all others in the system. This has the effect of reducing long runs of wiring from front to rear or top to bottom in a vehicle since all input/output information is available on the CAN/J1939 network.

3. VMM1210 Hardware and Software

3.1. VMM1210 Hardware

The VMM1210 hardware consists of the following:

- Infineon C167 microcontroller, 256 KB Flash, 64 KB SRAM.
- 8 general purpose digital inputs (programmable as active high or low and as power control inputs).
- 4 programmable inputs (programmable as analog, digital, or frequency).
- 5 dedicated address inputs.
- 8 general purpose high-side drivers (10 A per output rating, programmable PWM with programmable base frequency).
- 2 general purpose high-side/low-side outputs (programmable as high-side or low-side or as an H-Bridge).
- 2 high current bus bar inputs (supplies power to high-side drivers).
- 1 logic power input.
- 1 CAN/J1939 network port.
- 1 pseudo-RS232 programming port.

3.1.1. General Purpose Inputs

`INPUT1` to `INPUT8` on the VMM1210 are general purpose digital inputs (refer to section *6.1 VMM1210 Connectors and Pinouts* for more details on the connector pins). These inputs can be programmed as active high or active low and as power control inputs using the VMM software package.

- Active high inputs:
  - Generate an internal pull-down resistance of approximately 1 kohm allowing a floating state on the input to be recognized as inactive.
- Active low inputs:
  - Generate an internal pull up resistance of approximately 3.3 kohm allowing a floating state on the input to be recognized as inactive.

- Power control inputs:
  - Generate an internal signal in the module allowing it to "wake up" and turn on its main internal power supply. This wakes up the C167 main processor and allows ladder logic to process.
  - If no power control inputs are selected in the VMM software application, the VMM1210 "wakes up" as soon as power is applied to the unit.
  - The VMM system uses INPUT1 on each module for special purposes. If INPUT1 is active, the VMM assumes that all other VMMs are active in the system. It then performs Plug and Play functions as well as network fault functions based on the assumption that all modules are awake.

Warning: You must ensure that INPUT1 on each module in a system is dedicated as a "master power" input and give it power control functionality on each module if you want Plug and Play and network fault detection functionality.

  - In addition, at least one input on each module (the same input # on each module) should be dedicated as power control with the same activate state (i.e., active high or low). This allows VMM1210s to be swapped from location to location in a vehicle and still guarantee that they can be powered up in the new location. Since INPUT1 should be a power control driven from the same source on each module, it is a simple matter to ensure that INPUT1 has the same active state on each module as well. This will take care of both situations with a single input per module.

Warning: Swapping modules in a system from location to location may prevent the modules from powering up unless at least one power control is the same on each module and has the same active high/low setting.

  - Power control inputs can be programmed as active high or active low. If an input is programmed as power control and active low, you need a low (ground) signal on that input pin to wake up the module. If an input is programmed as power control and active high, you need a high (battery) signal on that input pin to wake up the module. If you change the active state of that input in ladder logic and download this change to the module, the signal connected to that input pin must also change states in order to wake up the module again via that input. For example, assume INPUT2 is programmed active high and power control and the wire harness has an active high dash switch connected to this input. Now assume we change the active state of this input from high to low and download this new logic to the module. The module will receive the new logic and immediately after download will turn off (assuming input 2 is the only active power control input during the download). The module will not turn on again until the signal to the INPUT2 pin is physically rewired such that it switches ground instead of battery.

Warning: Changing power control settings on a VMM1210 may prevent you from being able to wake up the VMM unless corresponding changes to your wire harness and/or input connection arrangement are made.

3.1.2. Programmable Inputs

`INPUT9`, `INPUT10`, `INPUT11`, and `INPUT12` on the VMM1210 are programmable inputs (refer to section *6.1 VMM1210 Connectors and Pinouts* for more details on the connector pins). These inputs can be programmed as analog, digital, or frequency type inputs.

- Analog inputs:
  - Allow an analog input voltage of 0 to 32 V.
  - Programmable gain values (1, 3.007, 4.022, 6.029).
  - Programmable attenuation values (1, 0.3061, 0.1807, 0.1282).
  - Gain values and attenuation values can be mixed and matched to produce other gains/attenuation factors.
  - Maximum internal voltage range is from 0 V to 4.096 V, so the maximum external voltage should produce an internal voltage of no greater than 4.096. If it does, the analog input will clamp at maximum value. Attenuations/gains should be selected to allow the external analog input to be mapped into the internal voltage space to maximize analog input resolution.
  - Analog readings by the module can be used in ladder logic as either voltage readings with accuracy of 0.1 V or as "raw" AD Converter 10-bit values with accuracy down to 1 bit (or 0.004 V)[1].

Note: If any of the programmable inputs are left floating and are programmed as analog type inputs, they may read non-zero values in ladder logic. To avoid this, either connect the floating pin to a grounded resistor externally or add some "attenuation" in ladder logic. Attenuation factors added in ladder logic add internal pull-down resistors on the input in question.

- Digital inputs:
  - Allow active low digital inputs.
  - An internal pull-up value of approximately 3.3 kohm is used to allow a floating input to be read as inactive.
  - Gain and attenuation is not selectable for inputs programmed as digital.
- Frequency inputs:
  - Allow a periodic waveform with frequencies ranging from 10 Hz to 10 kHz to be read as a frequency value.

[1] This 1 bit accuracy does not include initial error inherent in the AD Converter and the amplifier input. Additional error can result from long cable runs or mismatched grounds from sensor to module.

- An internal pull-up value of approximately 3.3 kohms can be turned on or off for this input type.
- Programmable gain values (1, 3.007, 4.022, 6.029) available.
- Programmable attenuation values (1, 0.3061, 0.1807, 0.1282) available.
- Gain values and attenuation values can be mixed and matched to produce other gains/attenuation factors.

3.1.3. Address Inputs

ADDR1, ADDR2, ADDR3, ADDR4 and ADDR5 are dedicated address inputs (refer to section *6.1 VMM1210 Connectors and Pinouts* for more details on the connector pins). These inputs are used to set the system address on the module such that it is unique among all other modules in the system. The maximum allowable addresses in a VMM system is 31 including all devices on the bus (VMMs, PGM, Telltales, etc.). These inputs are all low-side inputs with 10 kohm internal pull-ups to ensure that a floating pin is read as inactive by the module. The addressing arrangement is shown in Table 1, which shows the required inputs that need to be active and floating (active shown as 1, floating shown as 0).

Table 1: VMM System Addressing

Address Input #					VMM Address
1	2	3	4	5	
0	0	0	0	0	VMM 1
1	0	0	0	0	VMM 2
0	1	0	0	0	VMM 3
1	1	0	0	0	VMM 4
0	0	1	0	0	VMM 5
0	1	1	1	1	VMM 31

Address 32 is reserved for Parker Vansco internal test purposes and should not be used.

3.1.4. General Purpose High-Side Outputs

OUTPUT1 to OUTPUT8 on the VMM1210 are general purpose, high current high-side outputs. These have the following features:

- Current rating:
  - Each output is rated at a continuous current of 10 A.
  - All 8 outputs can be operated at 10 A output at the same time for a total module current of 80 A maximum.
- Over current fault protection:
  - Each output is capable of shutting down in the event that the output current goes higher than the over current shutdown set point for the module.
  - Over current set point is programmable via the VMM software. The value is programmable from 12 A down to 6 A on a module by module basis.
  - Over current shutdown time is set to approximately 1 second.

- Fault is reported as a flashing output LED and via CAN/J1939 messages.

- Short to ground fault protection:
  - Each output is capable of shutting down in the event that the output current goes higher than approximately 45 A.
  - Short to Ground shutdown time is less than 10 ms.
  - Fault is reported as a flashing output LED and via CAN/J1939 messages.
- Short to power fault detection:
  - Each output is capable of detecting a short circuit to battery power when the output is in the off (inactive) state.
  - Fault is reported as a flashing output LED and via CAN/J1939 messages.
- Open load detection:
  - Each output is capable of detecting open loads when the output is in the off (inactive) state.
  - This detection is programmable on or off on a module by module basis.
  - If programmed as on for the module, the detection process is programmable as active only at power up or on a periodic basis with adjustable time between checks.
  - If programmed as on for the module, certain outputs can be programmed as ignored in the detection scheme to prevent false readings on high resistance or high voltage drop loads such as LED lights.
- Pulse width modulation:
  - Outputs 1 to 8 have the ability to be programmed for PWM duty cycles.
  - Five unique programmable frequencies are available. OUTPUT1 to OUTPUT4 have individual frequency control and OUTPUT5 to OUTPUT10 have a single programmable frequency.
- Inductive load protection:
  - OUTPUT1 to OUTPUT8 are internally protected against 600V inductive loads as outlined in the *SAE J1455 Joint SAE/TMC Recommended Environmental Practices for Electronic Equipment Design* specification.
  - Inductive loads that produce a greater voltage or energy content than that shown in the *SAE J1455 Joint SAE/TMC Recommended Environmental Practices for Electronic Equipment Design* specification require the use of external back EMF/Transient suppression diodes when connected to any of OUTPUT1 to OUTPUT8.

3.1.5. General Purpose High / Low-Side Outputs

OUTPUT9 and OUTPUT10 on the VMM1210 are general purpose, low current, programmable high or low-side outputs. These have the following features:

- High/low-side programmability:

OUTPUT9 and OUTPUT10 can be programmed through the VMM software package to be

- High-side
- Low-side
- H-Bridge (controlled by activating the one you want to be high-side)
  - H-Bridge allows loads to be controlled by both high-side and low-side switches at the same time.
  - H-Bridge allows loads to have current reversed through them, which allows several load types to reverse direction (motors, solenoids, etc.).
  - Figure 3 and Figure 4 show a typical setup for an H-Bridge to show how the H-Bridge is used to reverse current flow direction.

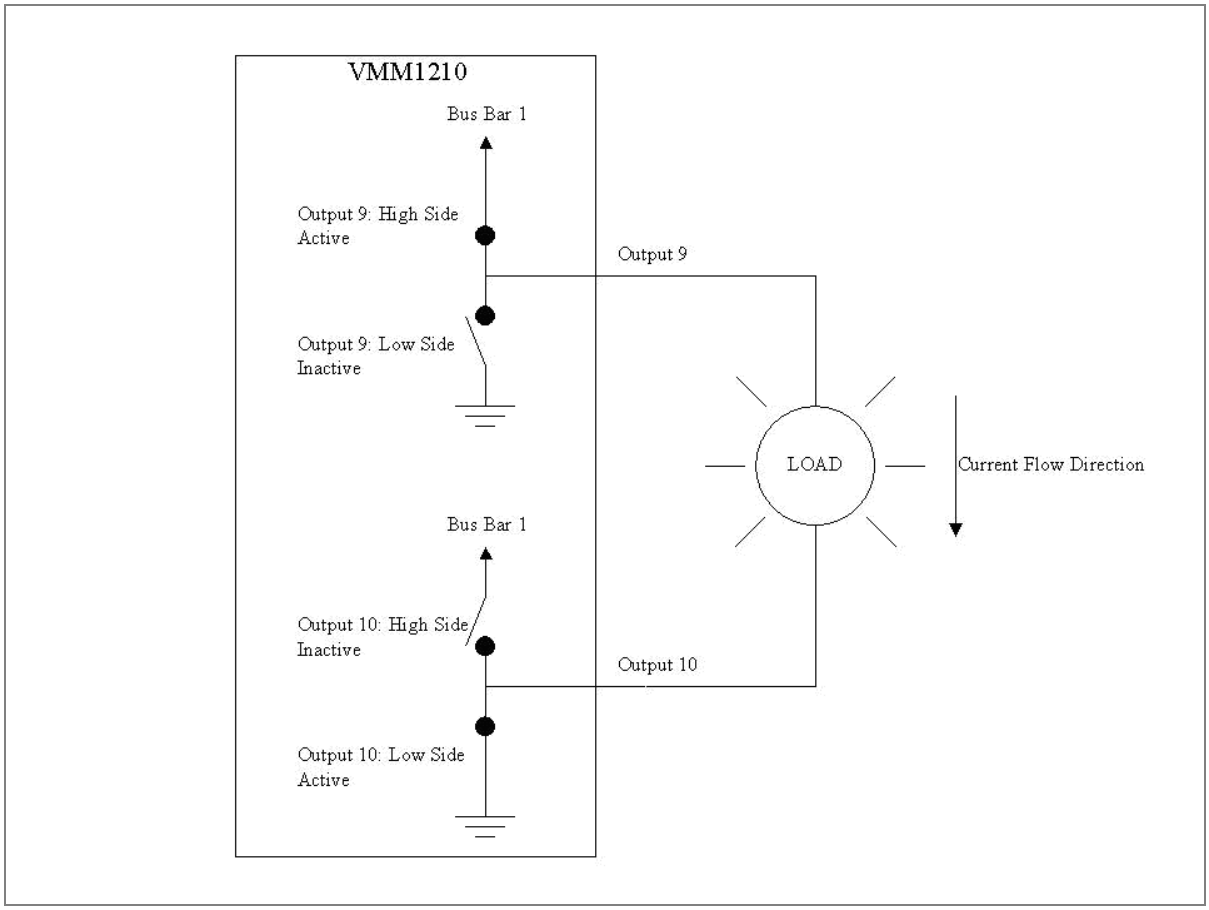


Figure 3: H-Bridge forward direction

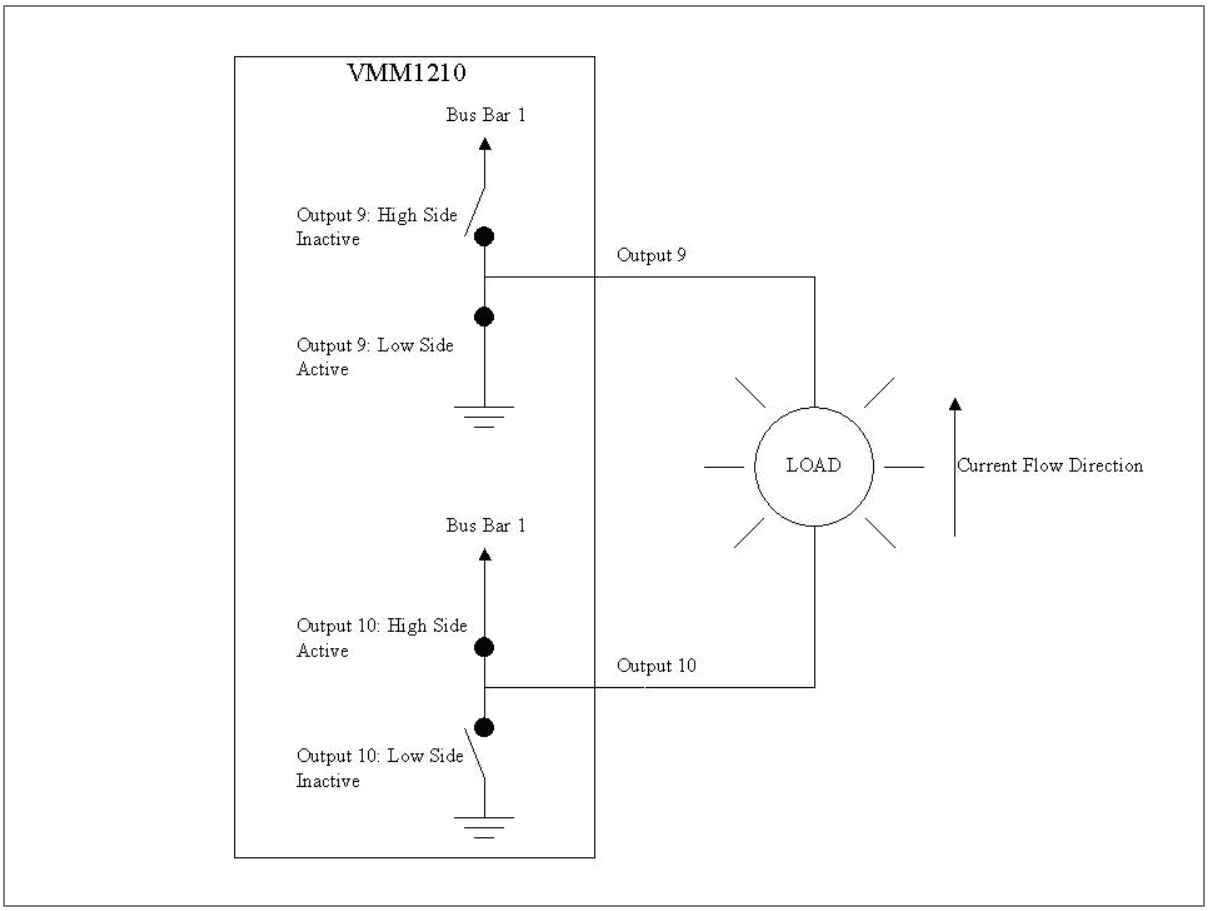


Figure 4: H-Bridge reverse direction

- To activate the H-Bridge as shown in Figure 3, the ladder logic should make `OUTPUT9` active and leave `OUTPUT10` inactive. To activate the H-Bridge as shown in Figure 4, the ladder logic should make `OUTPUT10` active and leave `OUTPUT9` inactive. If neither `OUTPUT9` nor `OUTPUT10` are active, all switches are off and `OUTPUT9` and `OUTPUT10` are floating. If both `OUTPUT9` and `OUTPUT10` are active at the same time, the output to go active first (i.e., the one that is processed first in ladder logic) will be high-side, the other will be the low-side. It is recommended that this situation be avoided by writing ladder logic to prevent both being active at the same time.

- Current rating:
  - Each output is rated at a continuous current of 3 A.
  - These outputs along with the other 8 outputs must have a total current of no more than 80 A per module.
- Short to ground fault protection:
  - Each output is capable of shutting down in the event that the output current goes higher than approximately 8 A.
  - Short to ground is performed in hardware using over temperature shutdown techniques.

- Fault is reported as a flashing output LED and via CAN/J1939 messages.

- Short to power fault detection:
  - Each output is capable of detecting a short circuit to battery power when the output is in the off (inactive) state.
  - Fault is reported as a flashing output LED and via CAN/J1939 messages.
- Open load detection:
  - Each output is capable of detecting open loads when the output is in the off (inactive) state.
  - This detection is programmable on or off on a module by module basis.
  - If programmed as on for the module, the detection process is programmable as active only at power up or on a periodic basis with adjustable time between checks.
  - If programmed as on for the module, certain outputs can be programmed as ignored in the detection scheme to prevent false readings on high resistance or high voltage drop loads such as LED lights.
  - Available on outputs 9 and 10 only if high-side driver is selected.
- Pulse width modulation:
  - OUTPUT9 and OUTPUT10 have the ability to be programmed for PWM duty cycles, excluding H-Bridge.
  - Five unique programmable frequencies are available. OUTPUT1 to OUTPUT4 have individual frequency control and OUTPUT5 to OUTPUT10 have a single programmable frequency.
- Inductive load protection:
  - OUTPUT9 and OUTPUT10 must be externally protected with back EMF/Transient suppression diodes if connected to an inductive load of any kind.

3.1.6. Power Connections

There are two main power connections, the high current bus bar battery power inputs (BUSBAR1 and BUSBAR2) and the low current logic power input (VBATT). The bus bar inputs are separated into two connectors of two wires each. Bus bar current flow greater than 20 A requires two wires in the connector, less than 20 A only requires one wire in the connector. To maintain product moisture sealing, if both wires are not populated, the spare location should be populated with a plug.

There is one main low current logic power connection (power and ground wire) that is required as the main power source for the VMM1210 circuitry. This draws low current (<500 mA) and should be connected to a power location with little voltage drop. This allows the VMM to take advantage of its full voltage range as well as prevent analog input shifts due to ground level shifts.

3.1.7. CAN / J1939 Network

The VMM1210's operate using an SAE J1939 network, which interconnects all VMMs (and other optional equipment) together. The physical cable for the J1939 network is three wires (J1939+, J1939-, and J1939 Shield) and should be connected to the VMM1210's J2 connector.

SAE J1939-11 calls for a main "backbone" cable, no longer than 40 metres, with 120 ohm terminators on each end. Other modules (such as VMM1210s) are connected to the backbone using wire stubs no longer than 1 metre. All stubs in the J1939 network should be different in length to reduce the possibility of standing wave interference on the network. All J1939 connections should be done using SAE J1939 specified connector types and cable types. At one point of the backbone, the cable shield wire should be securely connected to vehicle chassis ground to ensure adequate shielding on the network.

The connectors used to connect the J1939 network together (that is, connecting stubs and terminators to the backbone) consist of three pins and come in "T" or "Y" configurations so that you can branch off of the backbone. There are two manufacturers of J1939 connectors recognized by SAE, these are ITT Cannon and Deutsch. Both manufacturers offer terminator connectors with a 120-ohm resistor built in, but the ITT Cannon connectors have the advantage of easier terminal connections directly into the "Y" connector and fewer parts required (no secondary locks)[2]. See section *4.1 Installation* for further information on recommended J1939 connection requirements.

3.1.8. Pseudo-RS232 Programming Port

This RS232 port consists of hardware that can drive to +5 V and 0 V only, which is why it is considered a pseudo RS232 port. This pseudo port is only used for reprogramming of boot code, which will rarely, if ever, require updates by the customer. This port will typically never be used and should be left disconnected in a system application.

The BOOTSTRAP input on the VMM1210 is the third pin associated with the RS232 port and is required to place the VMM1210 into a special reprogramming mode. This pin should be left disconnected in a system application.

3.2. VMM1210 Software

The VMM1210 has the following three pieces of software on board during normal operation:

1. Boot code
2. Application code
3. Ladder logic

[2] For a complete list of J1939 connection considerations, please refer to the SAE J1939 specifications available through the Society for Automotive Engineers. The SAE J1939-11 specification covers the physical aspects of the network including cable type, connector type, cable lengths, etc.

3.2.1. Boot Code

The boot code acts as a base operating system for the VMM1210. It provides the ability to download other applications (such as ladder logic or application code) to the VMM1210 via the CAN/J1939 port. Boot code is downloaded to the product at the factory and is typically not upgradable by the end customer.

3.2.2. Application Code

The application code acts as the second level operating system for the VMM1210. It provides the I/O scanning functions, the I/O state transmission functions, the plug and play functions and the ladder logic processing functions. Application code is upgradable by the customer and can be downloaded to VMM1210s via the VMM software package through the CAN/J1939 network.

3.2.3. Ladder Logic

The ladder logic is the main program for the VMM1210, which allows the VMM1210 to perform tasks based on the user's requirements. Ladder logic is written using the VMM software package, a powerful, user-friendly windows-based application. Ladder logic is drawn on the graphical user interface and compiled, that is, converted into a format readable by the VMM1210. For more information on the VMM software, please refer to the VMM software user guide or the help files available within the VMM software application.

3.2.4. Updating the VMM1210 Software

The VMM1210 software can be updated with the use of the VMM software package. The software package provides the means to update Application Code as well as Ladder Logic. This update is done through the CAN/J1939 network using either a Parker Vansco Data Link Adapter (DLA) or PGM[3] to link the PC to the CAN/J1939 network.

To update software[4], go to the **Tools** menu and select **Download Logic**, **Download Application** or **Download PCM Application** as shown in Figure 5.

[3] The Parker Vansco DLA and the Parker Vansco PGM are both available to purchase as kits through Parker Vansco. For more information, please visit our Web site at www.vansco.ca.
[4] A special license key is required to allow ladder logic creation, editing and downloading. For more information, please refer to the VMM Software User Guide or contact the company that you purchased your vehicle or VMM1210 through.

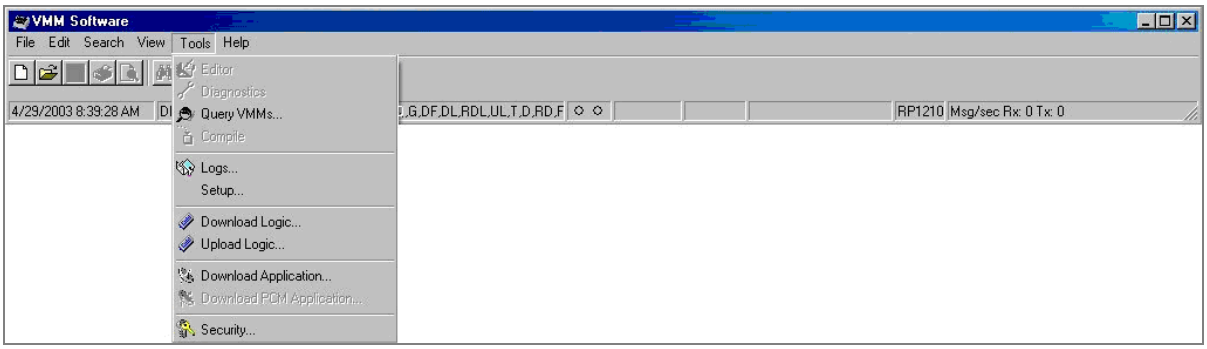


Figure 5: PC software Tools menu

Note: The software must be set up with a key that provides permissions to download any or all of these items. For keys or for more information on keys please contact the company that you purchased your vehicle or VMM1210s through.

3.3. PC Software Installation

The VMM software application is all that is required to generate and download ladder logic applications, diagnose electrical system problems and start using the VMM1210. The software is available through the company that you purchased your vehicle or VMM1210s through.

4. VMM1210 Installation and Setup

4.1. Installation

VMM1210 is mounted using four ¼" bolts. See Figure 6.

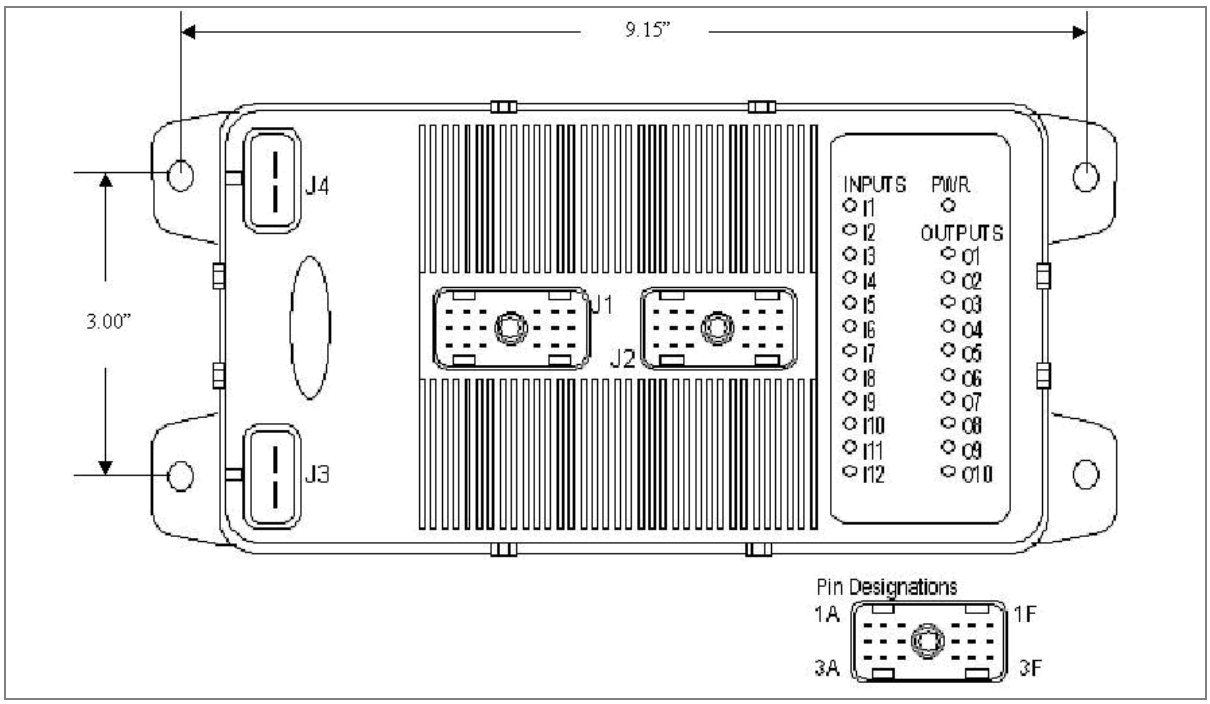


Figure 6: Installation dimensions

When attaching the VMM0604 to a vehicle, the following recommendations should be considered:

- Secure the VMM0604 with **bolts in all four bolt holes**
- Secure the VMM0604 using **¼"-20 Hex Head** or equivalent metric size (6 mm) bolts
- Refer to fastener manufacturer's recommendations for mounting bolt tightening torque

Note: The vehicle manufacturer is responsible for devising the procedures for mounting the VMM in a vehicle during production assembly.

- Both J1 and J2 connectors are required for normal operation of the VMM1210. These connectors provide access to the various inputs, outputs, network ports and logic power. The max torque for the J1 and J2 mating connectors should be 0.8 to 1.5 N-M (7 to 15 in-lb), according to the Packard specification.
- J3 and J4 provide power to BUSBAR1 and BUSBAR2 respectively, and are required if the outputs that get power from those bus bars are used. Any connectors left disconnected on the VMM1210 should be fashioned with dummy connectors with sealing plugs to prevent the contamination of contact pins.
- The Logic Power line (J1-1A) is connected to 12 Vdc or 24 Vdc. The Ground line (J1-3A) is connected to ground. It is recommended that the logic power and ground wires be kept isolated from high current power and ground studs where possible. This will prevent dips in the high current lines from affecting the power and ground signals at the VMM1210. For a system with a ground cable, see Figure 7. For a system where vehicle chassis is ground see Figure 8.
- The Bus Bar Power lines (J3-A/J3-B and J4-A/J4-B) are connected to 12 Vdc or 24 Vdc. Note that there are two pins on each of J3 and J4; these are internally connected on the VMM1210. Both pins on J3 and/or J4 need to be connected if the current flowing through an individual bus bar exceeds 20 A. It is recommended that the bus bar power wires be kept on a dedicated high current power connection point, isolated from the logic power wires where possible. For a system with a ground cable, see Figure 7. For a system where vehicle chassis is ground see Figure 8.

Warning: Proper fusing is required on any power wires coming off the battery terminal; this fusing is not shown in Figure 7 or Figure 8.

- The low-side output ground line (J2-1F) is to be connected to high current vehicle ground. This ground wire will be driving high load currents through low-side `OUTPUT9` and `OUTPUT10` (if programmed as low-side drivers and connected in the vehicle). For a system with a ground cable, see Figure 7. For a system where vehicle chassis is ground see Figure 8.

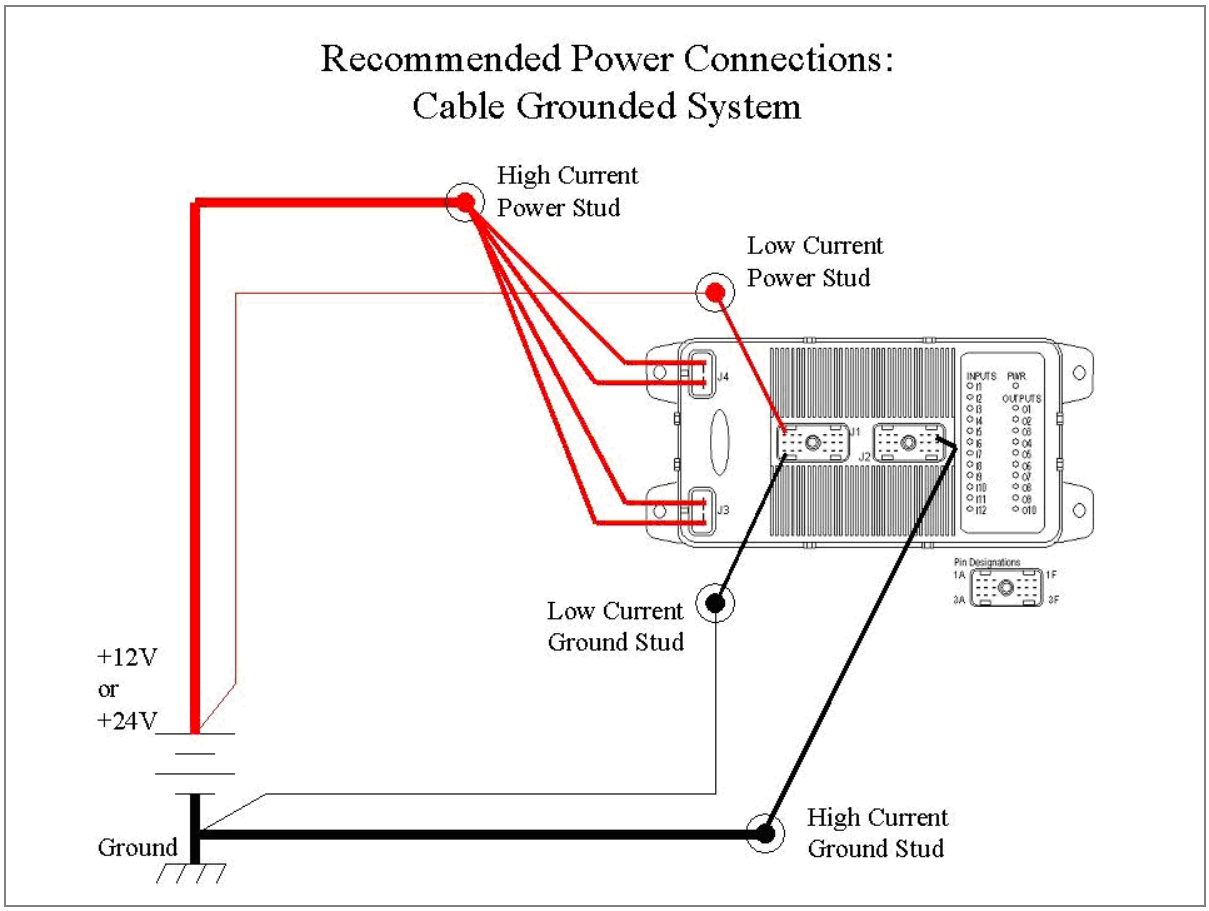


Figure 7: Cable grounded system

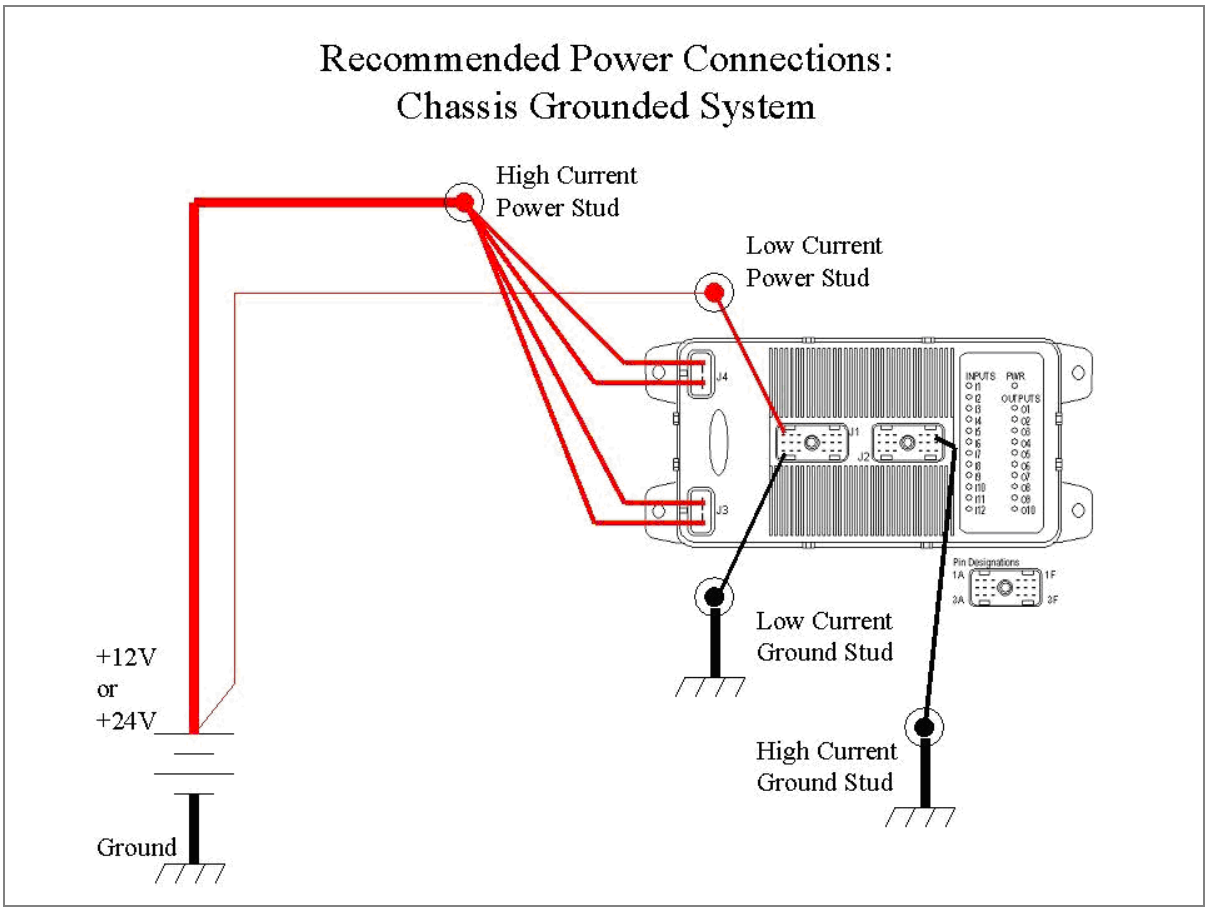


Figure 8: Chassis grounded system

- Inputs and outputs should be connected to the various items in the vehicle that you wish to have control over. The use of 16 AWG wire is required on output pins to ensure adequate sizing for over current protection. The use of 18 AWG or larger is recommended for use on the input pins. As an example, if you would like to have a VMM1210 control the vehicle headlights:
  - Run the headlights low beam and high beam switches to inputs on a VMM1210 using 18 AWG wire.
  - Run 16 AWG wires from the low beam bulbs to a VMM1210 high current output (e.g., `OUTPUT1`).
  - Run 16 AWG wires from the high beam bulbs to a VMM1210 high current output (e.g., `OUTPUT2`).
- Power Control Inputs should be run to each VMM1210 in the vehicle. Power control inputs allow the VMM1210 to wake up from its low power sleep mode. Since power control inputs are programmable, each module may have different power controls on different inputs.
  - In order to maintain the ability to swap modules from location to location, you must ensure that at least one input (the same input) on each module is selected as power control and has the same active state. This ensures that if

you swap a module from one location to the other, you will be able to power it up at the new location using this one power control input.

- `INPUT1`, as discussed in section *3.1.1 General Purpose Inputs*, is the "master power" input that if active, the VMM system assumes that all VMMs in the system are powered up. This is done for Plug and Play functionality as well as network fault detection. To enable both of these features your system must have `INPUT1` selected as power control on each VMM in the system and that these inputs are all activated through the same switch on the vehicle. This is usually connected to the ignition switch or master power switch. Doing this will also ensure that you meet the requirement above of having at least one input (the same input) set as power control and set to the same active state (i.e., active high or active low).

- CAN/J1939 connections require the use of 120 ohm twisted-pair-shielded-cable. There is cable on the market specifically designed for J1939 use and it is recommended that it be used when connecting the VMM1210 to a CAN/J1939 Network. The J1939 connections require the following:
  - Backbone be no longer than 40 m.
  - Stubs coming off the backbone to the VMM1210s be no longer than 1 m.
  - Stubs coming off the backbone to the VMM1210s be different lengths (e.g., VMM1 is connected with 1 m length; VMM2 is connected with 0.9 m length, etc.).
  - Connections from the backbone to the VMM1210s can be accomplished using either J1939 specified connectors or splicing. For the purposes of this specification we recommend the use of connectors over splicing for simplicity's sake. Figure 9 shows the J1939 recommended wiring scheme for a system, including recommended connectors. If splicing is to be done, please refer to SAE J1939 specifications for further info on recommended splicing practices.

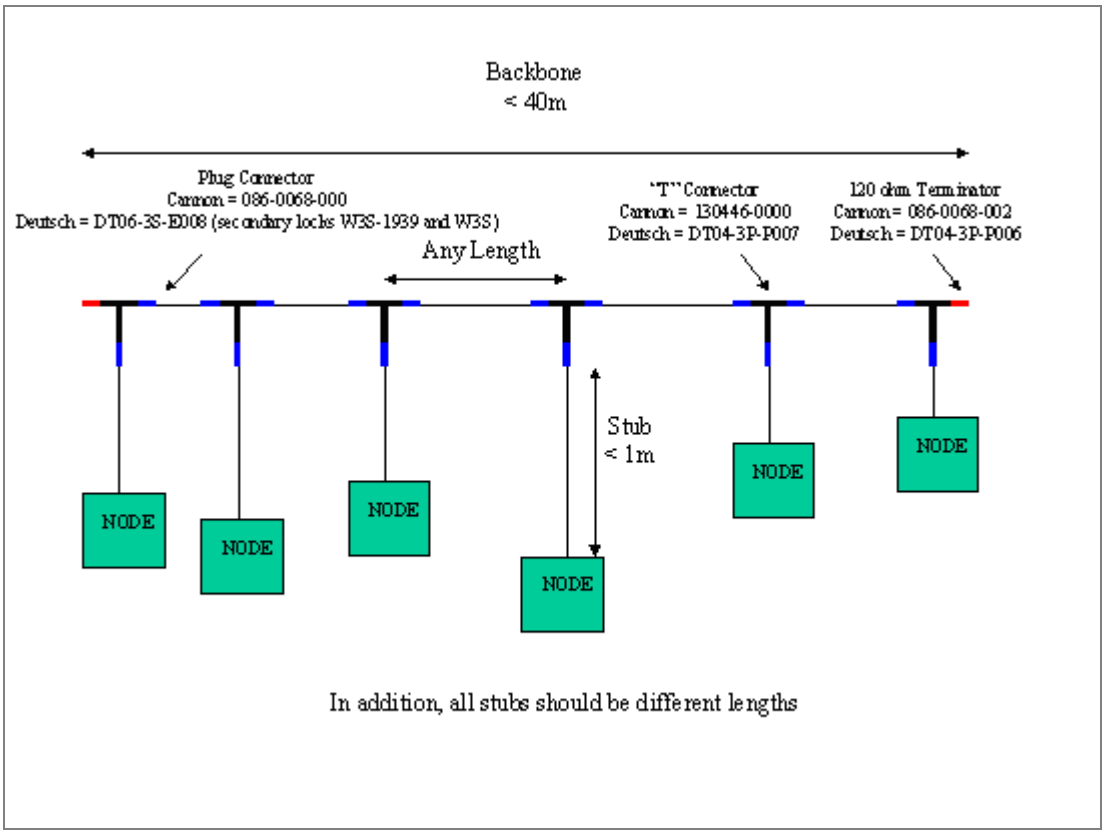


Figure 9: J1939 wiring arrangement

Figure 10 shows the connections to be made to connect the VMM1210 to the CAN/J1939 network. This is accomplished by connecting CAN high to J2-3F, CAN low to J2-3E, and CAN shield to J2-2F.

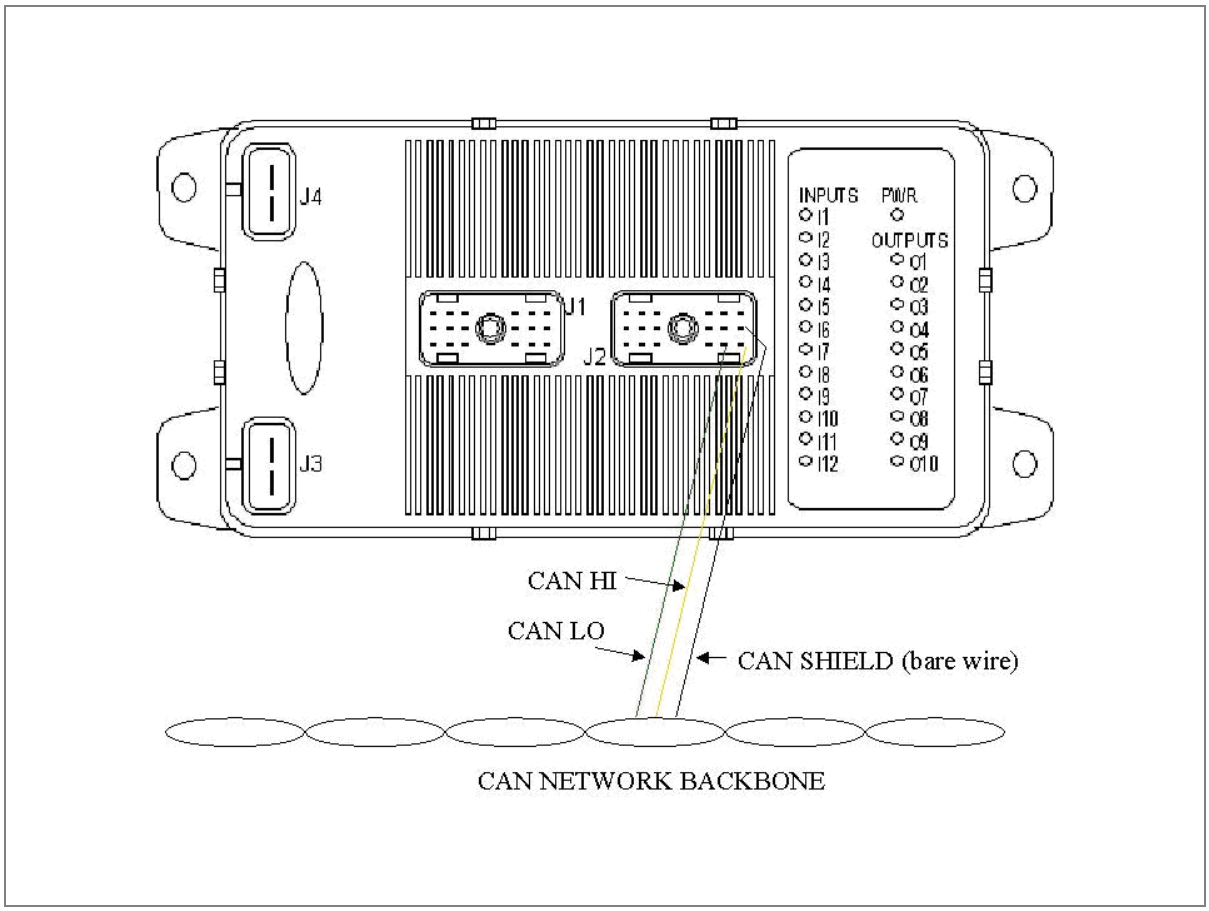


Figure 10: CAN/J1939 connection to the VMM1210

5. VMM1210 Specification

The VMM1210 Module design is based on specifications outlined in *SAE J1455 Joint SAE/TMC Recommended Environmental Practices for Electronic Equipment Design*. Please refer to the standard for full details.

The standards for EMC (radiated emissions and susceptibility) are *ANSI/ASAE EP455JUL91, Environmental Considerations in Development of Mobile Agricultural Electrical/Electronic Components* and *SAE J1113/1 Electromagnetic Compatibility Measurement Procedures and Limits for Vehicle Components (Except Aircraft) (60 Hz to 19 GHz)*.

5.1. Electrical / Environmental

General (+25ºC unless otherwise stated)

Test	Min	Nom	Max	Unit
Operating Voltage (Logic)[5]	7.0	12 to 28	32	V
Operating Over Voltage (5 Minutes)	-	-	48	V
Reverse Voltage (5 Minutes)	-	-	24	V
ESD Protection	-	-	15	kV
Operating Current Draw (Logic Power Pin)[6]	-	92	-	mA
Sleep Mode Current Draw (Logic Power Pin)[7]	-	22	-	mA
Additional Current Draw per Inactive Input (active low input type @ 13.8V, logic power pin)	-	0.66	-	mA
Additional Current Draw per Inactive Input (active high input type @ 13.8V, logic power pin)	-	7.4	-	mA
Current Draw per Active Input (active low input)[8]	-	4.3	-	mA
Current Draw per Active Input (active high input)[9]	-	13.8	-	mA

[5] Valid for hardware revision 2.4 and greater. For hardware lower than revision 2.4 the minimum operating voltage is 9.5 V.
[6] No inputs active, unit set up for no power control inputs so it is always on when power is applied. Input voltage 13.8V.
[7] No inputs active, unit set up for one power control input so sleep mode can be activated. All inputs programmed as active low type. Input voltage 13.8 V.
[8] Measured on active low input 1 pin, based on input pull up resistance. Input voltage 13.8 V.
[9] Measured on active high input 1 pin. Input voltage 13.8 V.

Test	Min	Nom	Max	Unit
Operating Temperature	-40	-	+85	°C
Storage Temperature	-55	-	+125	°C

Inputs (+25ºC unless otherwise stated)

	MIN	NOM	MAX	UNIT
# Digital Inputs	8	-	12	
# Analog Inputs	0	-	4	
# Frequency Inputs	0	-	4	
# Programmable Power Control Digital Inputs	-	8	-	
# Programmable Active High/Low Digital Inputs	-	8	-	
Active Low Digital Input Pull Up Resistance	2.9	-	3.5	kς
Active High Digital Input Pull Down Resistance	950	-	1050	ς
Active Low Inactive to Active Threshold [10]	0.9	-	2.05	V
Active Low Active to Inactive Threshold [12]	2.25	-	3.15	V
Active High Active to Inactive Threshold [12]	0.9	-	2.05	V
Active Low Inactive to Active Threshold [12]	2.25	-	3.15	V
Inputs 9 to 12 Inactive to Active Threshold	1.23	-	-	V
Inputs 9 to 12 Active to Inactive Threshold	-	-	2.6	V
Inputs 9 to 12 Pull Up Resistance	3.118	3.3	3.482	kς
Inputs 9 to 12 Pull Up Voltage [11]	-	VBatt – 0.7	-	V
Inputs 9 to 12 Analog Range	0	-	32	V
Inputs 9 to 12 Analog Internal Range [12]	-	4.096	-	V
Inputs 9 to 12 Analog/Freq Attenuation Factor	0.1282	-	1	
Inputs 9 to 12 Analog/Freq Gain Factor	1	-	6.029	
Inputs 9 to 12 Frequency Range	0	-	10	kHz
Inputs 1 to 8 Minimum Detectable Pulse Length	75	-	-	Ms
Input Pin Capacitance	-	0.01	-	uF

[10] Valid for inputs 1 to 8.
[11] Valid for inputs 1 to 8.
[12] You should ensure that you attenuate or boost an analog input signal such that you maximize the internal range to ensure the highest resolution possible on the analog reading. For example, an analog input signal with a maximum value of 13.38 V should be attenuated with 0.3061, which gives the analog an internal range from 0 to 4.096.

Outputs (+25ºC unless otherwise stated)

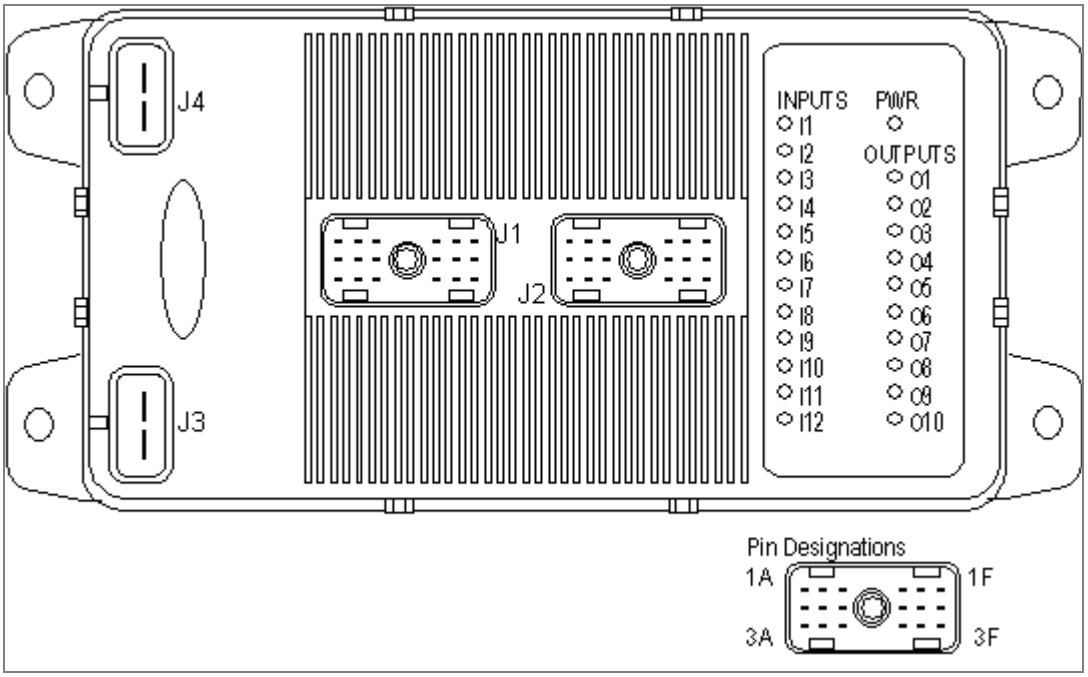
Test	Min	Nom	Max	Unit
# High-side Outputs	8	-	10	
# Low-side Outputs	0	-	2	
Max Continuous Current, Outputs 1 to 8	-	-	10	A
Max Continuous Current, Outputs 9 and 10	-	-	3	A
Over Current Trip Point, Outputs 1 to 8[13]	6	-	12	A
Over Current Trip Time, Outputs 1 to 8	-	1	-	s
Short Circuit Trip Point, Outputs 1 to 8	-	45	-	A
Short Circuit Trip Time, Outputs 1 to 8[14]	10	-	20	ms
Short Circuit Trip Point, Outputs 9 and 10 (high-side)[15]	-	8	-	A
Short Circuit Trip Point, Outputs 9 and 10 (low-side) [16]	-	28	-	A
Open Load Detect Pull-up Resistance	-	10	-	k Ω
Acceptable Voltage on Low-side Ground (J2-1F with respect to J1-3A)[16]	-1.0	0	2.0	V
Leakage to Battery, Outputs 9 and 10 Off State[17]	-	-	12	uA
Leakage to Ground, Outputs 9 and 10 Off State	4	-	-	k Ω
Leakage to Ground, Output 1 to 8 Off State	15	-	-	k Ω
Leakage to Battery Output 1 to 8 Off State	-	15	25	uA
Output Pin Capacitance	-	0.01	-	uF
Output 1 to 8 turn on time (Enable signal to 90%)	50	-	400	us
Output 1 to 8 turn off time (/Enable signal to 10%)	30	-	110	us
Output 1 to 8 Slew Rate – Rising Edge 10% to 30% Rload = 1Ω	1.0	1.5	2.2	V/us
Output 1 to 8 Slew Rate – Falling Edge 70% to 40% Rload = 1Ω	1.1	1.9	2.6	V/us
Output 9 and 10 high-side turn on time (Enable signal to 90%)	80	-	400	us
Output 9 and 10 high-side turn off time (/Enable signal to 10%)	80	-	400	us

[13] Default value is 12. Programmable within range shown.
[14] Short circuit time to trip will increase if the output is in a PWM state (time to trip increases as duty cycle decreases). This is because less average power is driven through a PWM output.
[15] Thermally protected device, trips off at approximately 150°C. The hotter the product, the less current required to trip it.
[16] This is the voltage range over which the low-side outputs will operate properly. Voltage differences from low-side ground to logic ground beyond these levels could result in the low-side outputs turning on or off unexpectedly.
[17] All leakage specs are for condition when open load detection is disabled.

Test	Min	Nom	Max	Unit
Output 9 and 10 high-side Slew Rate – Rising Edge 10% to 30% Rload = 12Ω	0.1	-	1	V/us
Output 9 and 10 high-side Slew Rate – Falling Edge 70% to 40% Rload = 12Ω	0.1	-	1	V/us
Output 9 and 10 low-side turn on time (Enable signal to 90%)	-	40	100	us
Output 9 and 10 low-side turn off time (/Enable signal to 10%)	-	70	170	us
Output 9 and 10 low-side Slew Rate – Rising Edge 50% to 70% Rload = 2.2Ω	-	1	3	V/us
Output 9 and 10 low-side Slew Rate – Falling Edge 70% to 50% Rload = 2.2Ω	-	1	3	V/us

6. Mechanical Footprint and Pinouts

6.1. VMM1210 Connectors and Pinouts



Connector J1
Product I/O connector
Mating connector: Packard Metri-pack # 12040925 or 15492547
Mating contact: Packard # 12103881

Connector Pin	Name	Output Bus Bar	Description
1A	VBATT	N/A	Connect to vehicle battery (operates down to 9 V and up to 32 V with 48 V protection)
1B	ADDR3	N/A	Switch to ground (active ground) used for selecting module address
1C	OUTPUT6	2	High-side output

Connector Pin	Name	Output Bus Bar	Description
1D	OUTPUT7	2	High-side output
1E	INPUT1	N/A	Programmable switch to battery or to ground Programmable power control
1F	OUTPUT8	2	High-side output
2A	INPUT2	N/A	Programmable switch to battery or to ground Programmable power control
2B	ADDR2	N/A	Switch to ground (active ground) used for selecting module address
2C	INPUT3	N/A	Programmable switch to battery or to ground Programmable power control
2D	ADDR4	N/A	Switch to ground (active ground) used for selecting module address
2E	ADDR1	N/A	Switch to ground (active ground) used for selecting module address
2F	INPUT4	N/A	Programmable switch to battery or to ground Programmable power control
3A	GND_POWER	N/A	Connect to vehicle ground
3B	INPUT5	N/A	Programmable switch to battery or to ground Programmable power control
3C	OUTPUT1	1	High-side output
3D	OUTPUT2	1	High-side output
3E	INPUT6	N/A	Programmable switch to battery or to ground Programmable power control
3F	OUTPUT5	1	High-side output

Connector J2
Product I/O connector
Mating connector: Packard Metri-pack # 12040921 or 15492546
Mating contact: Packard # 12103881

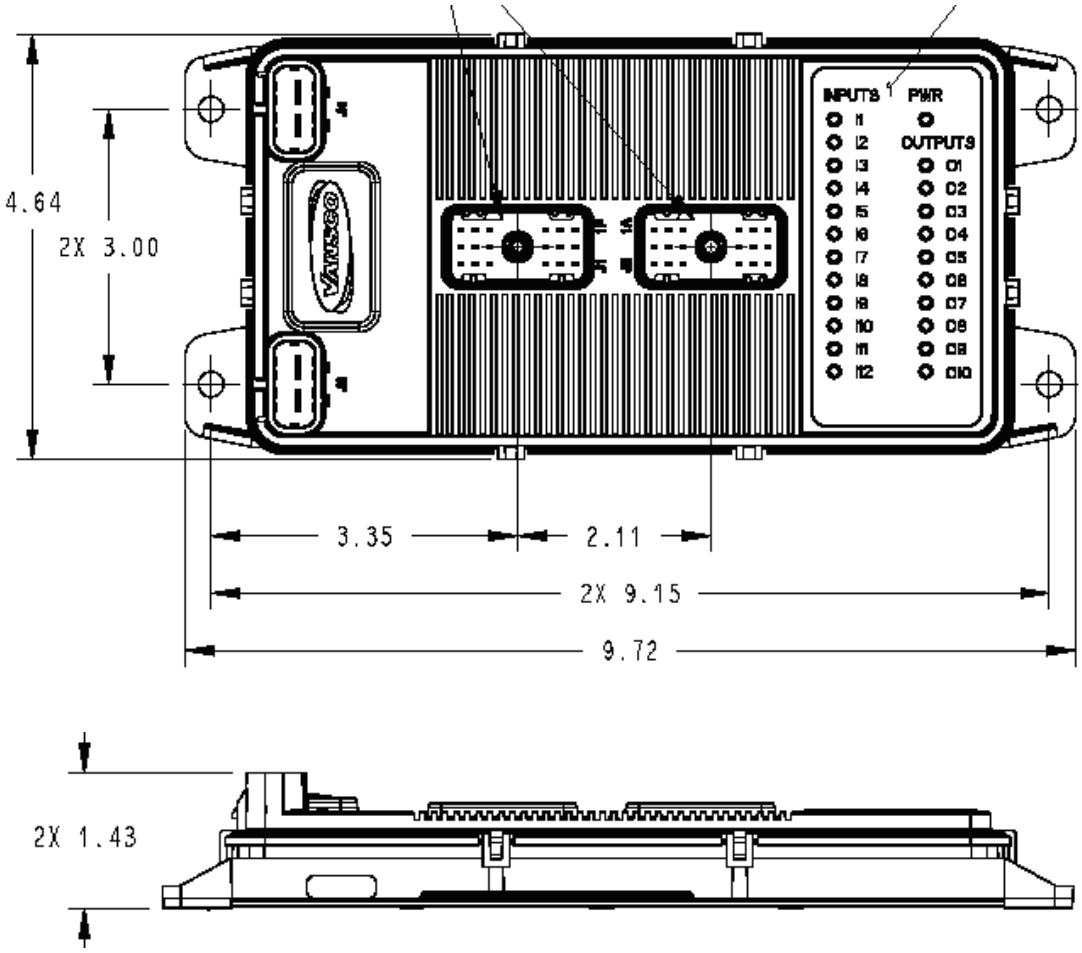
Connector Pin	Name	Output Bus Bar	Description
1A	RS232_RX	N/A	Serial communications, typically not used by customer
1B	INPUT8	N/A	Programmable switch to battery or to ground Programmable power control
1C	OUTPUT3	2	High-side output
1D	OUTPUT10	1	Programmable high-side/low-side/H-bridge (with OUTPUT9) output
1E	INPUT7	N/A	Programmable switch to battery or to ground Programmable power control

Connector Pin	Name	Output Bus Bar	Description
1F	LOWSIDE_GND	N/A	Connect to vehicle ground (note this is a higher current ground that the GND_POWER input above so it should be connected to a power stud)
2A	BOOTSTRAP	N/A	Serial communications, typically not used by customer
2B	INPUT9	N/A	Programmable digital switch to ground Programmable Analog with gain/atten control Programmable Frequency with gain/atten/pull-up control
2C	INPUT11	N/A	Programmable digital switch to ground Programmable Analog with atten control Programmable Frequency with atten/pull-up control
2D	INPUT10	N/A	Programmable digital switch to ground Programmable Analog with atten control Programmable Frequency with atten/pull-up control
2E	INPUT12	N/A	Programmable digital switch to ground Programmable Analog with atten control Programmable Frequency with atten/pull-up control
2F	CAN_SHIELD	N/A	CAN Communications, connect to shield of CAN wire
3A	ADDR5	N/A	Switch to ground (active ground) used for selecting module address
3B	RS232_TX	N/A	Serial communications, typically not used by customer
3C	OUTPUT4	1	High-side output
3D	OUTPUT9	1	Programmable high-side/low-side/H-bridge (with OUTPUT10) output
3E	CAN_LO	N/A	
3F	CAN_HI	N/A	

Connectors J3 and J4
Bus Bar Connectors
Mating Connector: Packard # 12033769
Mating Contact: Packard # 12033997

Connector Pin	Name	Additional Info
J3-A	BUSBAR1	Connect to vehicle battery (either 12V or 24V system, operates down to 6V and up to 32V with 48V protection). Powers outputs 1, 2, 4, 5, 9, 10.
J3-B	BUSBAR1	Connect to vehicle battery (either 12V or 24V system, operates down to 6V and up to 32V with 48V protection). Powers outputs 1, 2, 4, 5, 9, 10.
J4-A	BUSBAR2	Connect to vehicle battery (either 12V or 24V system, operates down to 6V and up to 32V with 48V protection). Powers outputs 3, 6, 7, 8.
J4-B	BUSBAR2	Connect to vehicle battery (either 12V or 24V system, operates down to 6V and up to 32V with 48V protection). Powers outputs 3, 6, 7, 8.

6.2. VMM1210 Mechanical Dimensions (Inches)



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7. Special Tooling: A tooling charge may be imposed for any special tooling, including without limitation, dies, fixtures, molds and patterns, acquired to manufacture items sold pursuant to this contract. Such special tooling shall be and remain Seller's property notwithstanding payment of any charges by Buyer. In no event will Buyer acquire any interest in apparatus belonging to Seller which is utilized in the manufacture of the items sold hereunder, even if such apparatus has been specially converted or adapted for such manufacture and notwithstanding any charges paid by Buyer. Unless otherwise agreed, Seller shall have the right to alter, discard or otherwise dispose of any special tooling or other property in its sole discretion at any time.

8. Buyer's Property: Any designs, tools, patterns, materials, drawings, confidential information or equipment furnished by Buyer or any other items which become Buyer's property, may be considered obsolete and may be destroyed by Seller after two (2) consecutive years have elapsed without Buyer placing an order for the items which are manufactured using such property, Seller shall not be responsible for any loss or damage to such property while it is in Seller's possession or control.

9. Taxes: Unless otherwise indicated on the face hereof, all prices and charges are exclusive of excise, sales, use, property, occupational or like taxes which may be imposed by any taxing authority upon the manufacture, sale or delivery of the items sold hereunder. If any such taxes must be paid by Seller or if Seller is liable for the collection of such tax, the amount thereof shall be in addition to the amounts for the items sold. Buyer agrees to pay all such taxes or to reimburse Seller therefore upon receipt of its invoice. If Buyer claims exemption from any sales, use or other tax imposed by any taxing authority, Buyer shall save Seller harmless from and against any such tax, together with any interest or penalties thereon which may be assessed if the items are held to be taxable.

10. Indemnity For Infringement of Intellectual Property Rights: Seller shall have no liability for infringement of any patents, trademarks, copyrights, trade dress, trade secrets or similar rights except as provided in this Part 10. Seller will defend and indemnify Buyer against allegations of infringement of U.S. Patents, U.S. Trademarks, copyrights, trade dress and trade secrets (hereinafter 'Intellectual Property Rights'). Seller will defend at its expense and will pay the cost of any settlement or damages awarded in an action brought against Buyer based on an allegation that an item sold pursuant to this contract infringes the Intellectual Property Rights of a third party. Seller's obligation to defend and indemnify Buyer is contingent on Buyer notifying Seller within ten (10) days after Buyer becomes aware of such allegations of infringement, and Seller having sole control over the defense of any allegations or actions including all negotiations for settlement or compromise. If an item sold hereunder is subject to a claim that it infringes the Intellectual Property Rights of a third party, Seller may, at its sole expense and option, procure for Buyer the right to continue using said item, replace or modify said item so as to make it noninfringing, or offer to accept return of said item and return the purchase price less a reasonable allowance for depreciation. Notwithstanding the foregoing, Seller shall have no liability for claims of infringement based on information provided by Buyer, or directed to items delivered hereunder for which the designs are specified in whole or part by Buyer, or infringements resulting from the modification, combination or use in a system of any item sold hereunder. The foregoing provisions of this Part 10 shall constitute Seller's sole and exclusive liability and Buyer's sole and exclusive remedy for infringement of Intellectual Property Rights.

If a claim is based on information provided by Buyer or if the design for an item delivered hereunder is specified in whole or in part by Buyer, Buyer shall defend and indemnify Seller for all costs, expenses or judgments resulting from any claim that such item infringes any patent, trademark, copyright, trade dress, trade secret or any similar right.

11. Force Majeure: Seller does not assume the risk of and shall not be liable for delay or failure to perform any of Seller's obligations by reason of circumstances beyond the reasonable control of Seller (hereinafter 'Events of Force Majeure'). Events of Force Majeure shall include without limitation, accidents, acts of God, strikes or labor disputes, acts, laws, rules or regulations of any government or government agency, fires, floods, delays or failures in delivery of carriers or suppliers, shortages of materials and any other cause beyond Seller's control.

12. Entire Agreement/Governing Law: The terms and conditions set forth herein, together with any amendments, modifications and any different terms or conditions expressly accepted by Seller in writing, shall constitute the entire Agreement concerning the items sold, and there are no oral or other representations or agreements which pertain thereto. This Agreement shall be governed in all respects by the law of the State of Ohio. No actions arising out of the sale of the items sold hereunder or this Agreement may be brought by either party more than two (2) years after the cause of action accrues